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Ellis, Grace Frances
The origin of life; a girl's physiology.

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The Edith H. Gordon
Bequest - 1940

in memoriam

Edith Hamilton Gordon
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First Medical Adviser of Women Students
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From 1921 to 1939

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Education for Women Students

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London –

Mrs. W. H. White –

The
ORIGIN OF LIFE

A Girl's Physiology

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GRACE F. ELLIS
CENTRAL HIGH SCHOOL
GRAND RAPIDS, MICHIGAN

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The Origin of Life

A Girl's Physiology

> If anything is sacred, the
> human body is sacred.
> *Whitman*

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GRAND RAPIDS, MICHIGAN

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Introduction

This little book was designed to be a chapter in a physiology used by high school students. Such a chapter cannot at present —and perhaps not ever—be wisely incorporated in the text, but this fact does not obviate its necessity, or limit its usefulness.

It is a long time now, since Huxley said of physiology texts that if they were to be inspected by visitors from another planet, or by a later age, it would be concluded that man had been a sexless animal. We have finally learned that sex and its manifestations are not subjects to be avoided, but rather they are to be treated scientifically and openly, so that from them as well as from the lesser facts of life, we may gather inspiration for better living and cleaner thinking. It is with this object in mind that this book has been prepared for my own students. It is dedicated to the hundreds of girls in Grand Rapids Central High School whose sympathy has given the use of this book success, and whose appreciation has made the work a pleasure, with the hope that a better understanding of the wonder and sacredness of life may add to their preparation for living.

If it may also serve to establish clearer ideals in the lives of other young women as well, it will fulfill all that the writer hopes for its use.

GRACE F. ELLIS.

CHAPTER I.

CELL GROWTH AND DIVISION.

The microscope shows us that all living things are made up of very tiny parts called cells. The number of cells in one's own body is inconceivable, but no matter how many or how small, each one is composed of a particle of living substance which we call protoplasm. This protoplasm, or life-stuff, is made up of a substance much like white of egg or albumen, and so universal is the presence of cells containing this in animals and plants, that the cell has been called the unit of life. Within this cell is a denser mass of protoplasm called the nucleus, and enclosing the cell structures is a thin, delicate cell wall.

The lowest forms of plants and animals alike, are only single cells, while the highest forms of animal and plant life like ourselves, are composed of uncounted millions of such cells. No matter how many cells a living thing contains, each of these cells was formed by the division of some cell which preceded it, and no cell is ever brought into being except as the result of the growth and separation of some other cell into parts. The division of the cell begins with the nucleus, which goes through a number of changes before it finally separates into two parts. When this occurs the protoplasm of the cell also separates, a wall appears across the middle, and two cells take the place of one.

Plants and animals which consist of a single cell increase in numbers by the division of the cell into parts. In such a cell after the nucleus has divided so that each new cell may have a nucleus of its own, a groove forms about the center of the cell, new cell walls form, and the cells separate and float apart. The parent cell has at once become two daughter-cells, each of which will subsequently grow and divide. Such one-celled animals and plants as you might dip up in abundance in a pailful of pond water, have in many cases no other form of reproduction than this simple division.

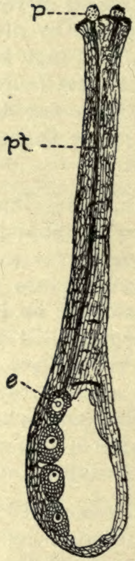
In other cases, before division takes place two like cells come together, each nucleus divides, and exchanges a part of its substance with the other nucleus. The cells then separate and divide actively for many generations. Such a temporary union as this is known as conjugation, which means being yoked together. It seems to act as a sort of renewal of life to the cells, so that for a long time growth and division go on very rapidly.

Plants like the common molds which attack foods to the annoyance of the housekeeper, are composed of a number of cells, some of which act as a sort of root, or hold fast, to attach the plant, and others reproduce by division into a great many small parts called spores, which may be blown or floated about and so find more room for development. The dark powdery material on bread-mold, and the fine dust inside a ripened puffball, consist of millions of these spores, each of which has the ability to form a new plant.

One-celled animals sometimes multiply in the same way; a cell will secrete a thick wall about itself, sink to the bottom of the water, and become quiet for a longer or shorter period of time. Then it will break up into a number of small parts which separate, each part to take up its life for itself. At one stage in the life of the single-celled animal which causes malarial fever, multiplication takes place in this way in the blood corpuscles. This is called asexual (without sex) reproduction, because the cells are similar, and where this occurs the child resembles the parent, because it is a part of the parent's body which has acquired an individuality and being of its own.

In all animals above the one-celled forms and in most plants, the lasting union of two different cells is necessary for reproduction; and in the higher plants this union of cells which is necessary to make the seed productive is called fertilization. The cells which take part in this are the pollen cells, powdery cells easily recognized in large flowers such as lilies, and the ovule (egg) which is not seen since it is buried in the part of the flower which is to become the seed. This is known as the pistil, and when pollen from one flower is carried to the pistil of another, we speak of it as cross-fertilization, and under such conditions the best seed is produced. In this process the pollen cell which rests on the pistil sends a slender tube down to the ovule in the ovary. Through this tube a particle of the nucleus of the pollen cell passes to join the nucleus of the ovule. The ovule thus becomes a seed with a capacity for growth and development. (See Fig. 1.)

Fig I.



Longitudinal section through a carpel

Showing the pollen, p, attached to the stigma, and protruding, its pollen tube, pt, which has pushed its way through the style to the egg, e, enclosed in the ovule.

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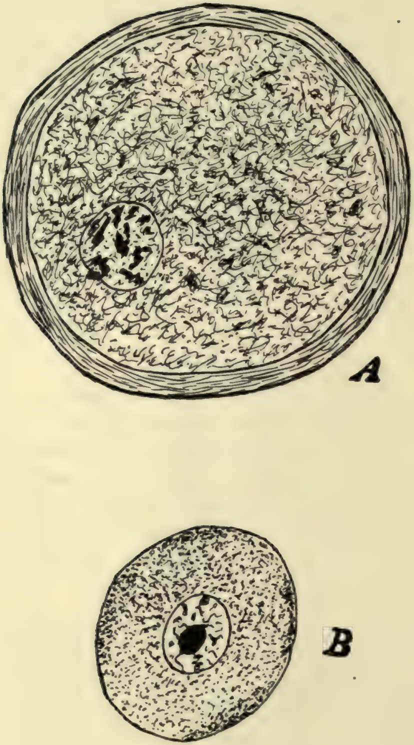
The fertilization of flowers, therefore, a form of sexual reproduction in which the pollen represents the male and the ovule the female element. This form of reproduction occurs widely throughout all classes of plants and animals and is the only method of producing young among the higher groups of animals. Fertilization, or sexual reproduction, always implies the existence and union of two kinds of cells, the egg cell, and the male or sperm cell. The eggs of all animals and plants consist of single cells in which the nucleus is very noticeable.

Eggs are generally ball-like in shape though they may vary. In size they range all the way from eggs too small to be seen without a microscope, to the size of an ostrich egg. The size of an egg does not depend on the animal producing it, for the human egg is microscopic and a hen's egg is enormous in comparison. (Fig. 2.) Such eggs as the hen's are almost altogether food material. The germ from which the chick develops is a small whitish spot on one side of the yolk. All the remainder of the egg is food for the growing chick during its three weeks of incubation.

The eggs of animals are formed in organs called ovaries. The ovaries of a fowl will be recognized as the mass of yolks attached in a bunch to the backbone of which one will be as large as the yolk of an egg, and the others will grade down in size to those which are very minute. After the egg of the hen begins its passage along the oviduct (or egg-tube) the white is added. The ovaries are differently placed in different animals, but their only function is to form eggs.

After the egg cell is formed in the ovary, in order that further development may take place, this egg cell must unite with a sperm cell. The sperm cells are very small, usually somewhat tadpole-like in shape, and consist of a tiny head, attached to which is a slender movable tail. The movements of this tail propel the sperm cell along until it meets the egg-cell. The head then penetrates the egg cell, and the two nuclei unite after changes which will be more fully discussed later on. This union of egg cell and sperm cell is called fertilization, and the moment the union occurs is the beginning of a new life and another individual.

Fig 2



EGGS. A, OF AN ANIMAL;
B, OF A PLANT.

WJS

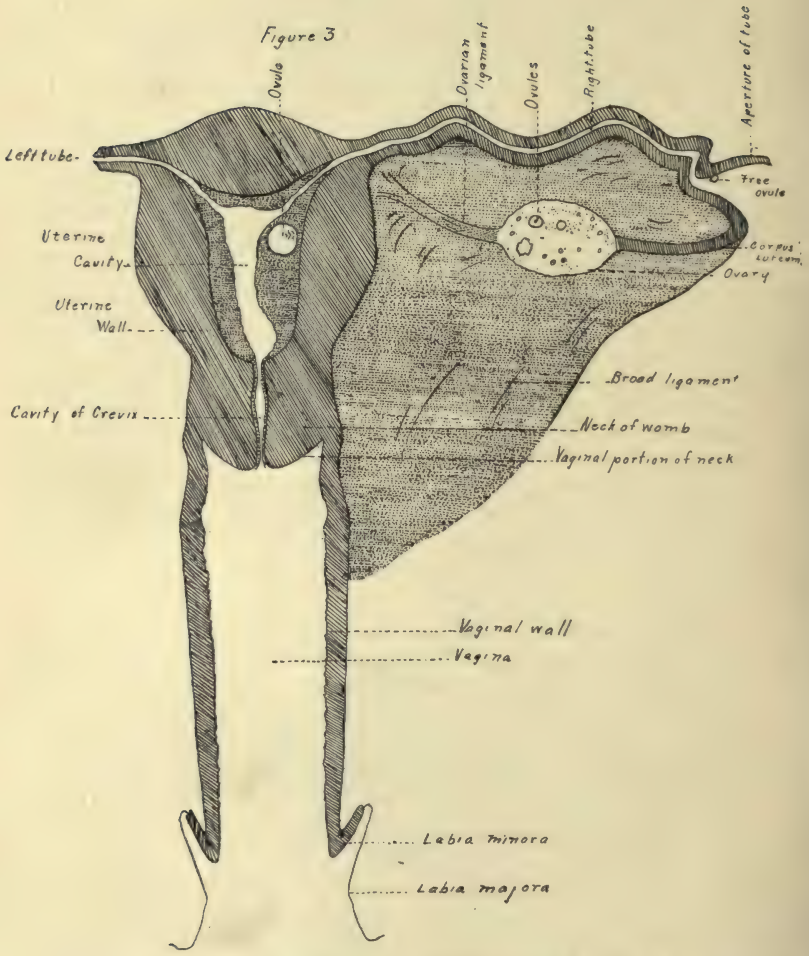
Fertilization of the egg is effected in different ways in different animals. In the clams and oysters the eggs are held in sacs in the body of the female, and the sperm cells are set free in the water by the male. The currents of water drift the sperm cells into the open shell of the female, and union of egg cell and sperm cell is more or less a matter of chance.

Frogs and toads lay their eggs in the water, the male at the same time depositing the sperm cells over them. Many fish leave the fertilization of eggs to occur in the same manner, and since these animals occur in great numbers in limited areas, the fertilization of the egg is usually accomplished.

Naturally, land animals cannot discharge their sperm cells in this manner with any certainty that the eggs will be fertilized. Therefore, the male introduces the sperm cells into the body of the female, where they are received in a special sac-like organ provided for this purpose. Here in many cases, they may be held until they are needed, as in the queen-bee. In her wedding-flight when she quits the hive by herself and flies high in the air, she is followed by the drones. She receives from the strongest of them, who is able to overtake her in her journey, at one time, sperm cells enough to fertilize all the millions of worker eggs she may afterward lay during a life-time of perhaps six years.

In the higher animals fertilization occurs more frequently, and the sperm cells work their way by means of their motile tails into the passages of the oviducts, through which the eggs must pass from the ovaries and there fertilize them. This process and the subsequent development of the egg necessitates the development of a complicated system of reproductive organs in which the egg may be formed and fertilized and have an opportunity to develop.

Figure 3



Diagrammatic section in median plane of female genital organs

Redrawn by
Eula Wood

CHAPTER II.

THE REPRODUCTIVE ORGANS.

The structure of the reproductive organs is our first concern in the study of human reproduction. In an adult woman this system includes the ovaries, and their tubes, the oviducts, the uterus, and the vagina. These organs are located in the lower part of the abdominal cavity known as the pelvis; and are the ones usually meant when the term pelvic organs is used. (Fig 3.)

1. The **ovary** is a dense oval mass about one and one-half inches in length, three-quarters of an inch wide, and one-half inch thick. It weighs from four to seven grams. The ovaries are two in number and one lies on each side of the pelvic cavity well inside the hip bones. Each ovary is enveloped and held in place by a fold of thin membrane which lines the abdominal cavity, and runs out from the backbone as a kind of sling to hold all the organs in place. Both blood vessels and nerves enter the ovary at its upper border.

2. The egg cells, commonly called the ova (sing. ovum), are produced within the ovaries. From time to time an ovum comes to the surface of the ovary, bursts through the covering membrane, and passes into the wide fringed opening of the oviduct (called Fallopian tubes in the human being). The opening of the Fallopian tube is partly shown in Fig. 3. The fringed edges of the tube could not be shown in the diagram. These partly enclose the ovary and as they and the tubes are lined with fine hairs (called cilia) which constantly wave the ovum along, it finally reaches the uterus.

3. The uterus is a hollow organ with thick muscular walls, which receives the ovum, and provides a place for its development if it is fertilized. Fertilization probably takes place in the Fallopian tube, the sperm cell working up into the tube by the motion of its tail. The uterus, sometimes called the womb, lies in the pelvis between the bladder and the rectum. The Fallopian tubes open into the upper part, at each side of the uterus. The constant close contact of rectum and uterus explains the effect of constipation in causing or aggravating uterine troubles. When fully developed the uterus is about three inches long, somewhat pear-shaped, but flattened from front to back. It is two inches

in breadth at its upper widest part and an inch in thickness. It weighs from twenty-five to forty-two grams (seven-eighths to one and one-half ounces). The upper wide part of the uterus is known as the body. The neck enlarges again somewhat before it ends at the upper part of the vagina. Within the cavity of the uterus the egg develops if it has been fertilized. During development it is spoken of as the embryo. The bulk of the uterus consists of a muscular coat arranged in two layers, a thin outer layer running lengthwise of the organ, and a thicker inner layer composed of oblique and circular fibers. Inside, the uterus is lined with a mucous membrane similar to that lining the alimentary canal, but having fine hairs on its surface. This mucous membrane lining contains tubular glands, blood vessels, and lymphatics.

Externally, the uterus is covered and held in place by the lining membrane of the abdomen (peritoneum), bands of which extend from each side of the uterus as the broad ligaments. Short, round ligaments assist in holding the uterus in place from front to back.

4. The **vagina** is the passage leading from the uterus to the exterior. At the back it rests against the rectum, in front against the bladder. The vagina is made up of muscular tissue lined by mucous membrane, and at its lower end has a circular muscle.

5. The external opening of the vagina is closed by the **hymen,** a fold of mucous membrane arising from the edge of the vaginal opening, and acting as a perforated diaphragm to separate the vagina from the vulva, or external parts of the reproductive apparatus.

6. The vulva consists mainly of the outer and inner labia, two thickened folds of flesh on either side, the outer pair being somewhat larger and longer, and enclosing the inner.

CHAPTER III.

THE MEANING OF PUBERTY.

The condition of the reproductive organs, which has just been described, is that found in the adult woman. To a certain extent, this is developed before birth and during childhood. These parts, however, grow but slowly and remain functionally incapable during the early years of life. Then there is a period of comparatively rapid increase in size, they become physiologically active, and the boy or girl becomes a man or woman.

Children do not differ greatly because of sex, but in this period of attaining sexual maturity, known as puberty, the differences due to sex become very marked. The earlier development of the girl, as compared with the boy, at the time of puberty, is a constant phenomenon to be observed in all races, in every climate and in all strata of society. According to statistical data, the age of greatest development in the respective sexes is:

	In the Female.	In the Male.
As regards weight at the age of	12 to 14 years	14 to 17 years.
As regards height at the age of	12 to 13 years	12 to 15 years.
As regards respiratory capacity	12 to 15 years	12 to 15 years.
As regards muscular strength	12 to 14 years	14 to 15 years.

Puberty occurs in the girl on the average about two years earlier than the boy, and upon this difference, the observed differences in growth also depend. It is earlier in warmer regions. Not only is it preceded and accompanied by acceleration in growth, but other bodily alterations also occur; in the boy there is an increase in strength, growth of beard, and change of voice. The latter is due to a sudden general enlargement of the laryngeal cartilages and lengthening of the vocal cords. In the girls the oncoming of puberty is marked by the appearance of menstruation, in the majority of girls, in temperate climates at the age of fourteen to seventeen. Other characteristic changes occur. The pelvis widens, the uterus develops, the figure becomes a woman's by the development of fat tissues in layers below the skin. The mental faculties mature, and the girl becomes a woman earlier, and more rapidly, than the boy becomes a man.

Hormones: These changes are apparently brought about in the body by the substances furnished by the reproductive glands to the blood and so carried throughout the body. While it is impossible to say what these substances are, the removal of the glands and the consequent lack of their secretions is very strongly shown throughout the whole body. These secretions which act as "chemical messengers" are called hormones.

Castration: "This is strikingly shown among animals. The young male is castrated. The parts removed are in no sense vital, and they seemingly have no connection with the other organs of the body. All the bodily functions, except reproduction proceed, but not as before." In general, the development of shoulder and neck will be arrested and they will remain lighter and finer. The voice, nervous temperament, disposition and general activity of the body are all affected. The hair of face and neck, in cattle, will be finer and less curly.

In hogs, the tusks and shoulder plates do not develop. The growth of the horns is lessened in sheep, but in cattle the only effect is to make the horns longer and a little more slender, approaching the female type. The hinder parts of the animal, as a whole, develop rather more in castrated than in entire animals, and there is a general approach to the female. Females deprived of their ovaries, develop, to some extent, the characteristics of the male, Speyed heifers are not at all like bulls, but they resemble steers; unsexing animals seem to give rise to a sort of half-way development. In this connection it remains only to mention the fact that among human beings "many individuals of each sex seem to be naturally endowed with more than the usual proportion of the characters of the opposite sex, and to be correspondingly short of their own." Thus, we speak commonly of mannish women, or effeminate men, distinguished by taste, occupations and physical peculiarities.

The sexual life of woman is the mainspring of the well being and progress of the family, the nation and the race. In the evolution of man from primitive conditions where he might be said to have existed for vegetative functions, up till now, in the highest stage of culture he has ever reached, in all races and under all conditions the sexual life has been the most active factor. To it, have been most intimately related religion, philosophy, ethics, natural science, and hygiene. The history of the development of sexual life would mark also the development of human culture in a primitive society. Among the lower races of mankind a woman was a chattel, neither highly esteemed nor carefully safeguarded.

Gradually, however, a change has come about, so that since the earliest stages of social life, the modesty of young girls, the preservation of virginity in young women, the respect for the mother, have had a civilizing effect upon the race. As family life has developed, and love and marriage have been more highly esteemed, woman has come to symbolize all that is beautiful and good, and all that is summed up in the idea of the housewife, and, in consequence, the sexual life has been more highly regarded. Kisch says in this regard, "The danger is not remote, however, that the leveling tendencies of the present day, and the inclination to despise the sexual life of woman, far from resulting in a further elevation of the social status of womanhood, will result rather in its abasement."

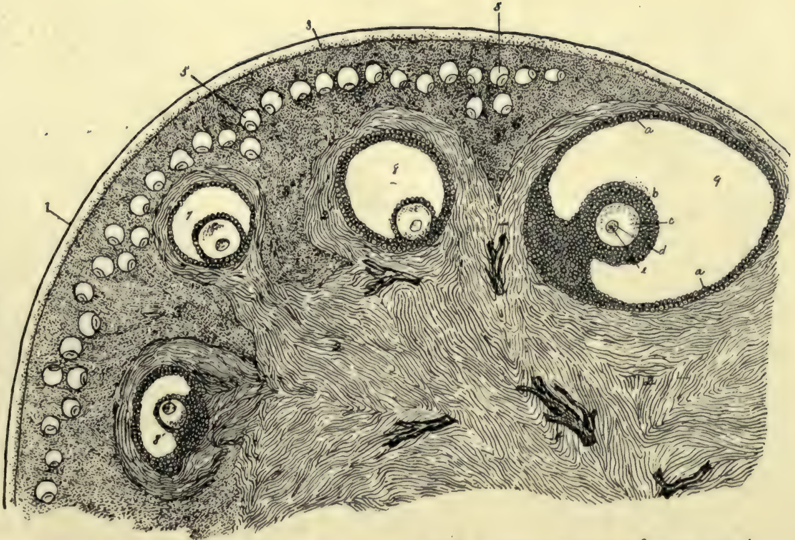
It is to be remembered, in all studies of this subject, that since all human life and being has its origin in sexual relations, these sexual relations may be regarded as the heart of the race.

"We may work day and night for the good of the race, we may sacrifice for that good, our time and our blood; but all this work and all this sacrifice appear, to me, to remain useless, if we neglect and despise the sexual life, the eternally self-renewing elementary school of true altruism."

Then after that period, in which marked by the oncoming of puberty and the first appearance of menstruation, ovulation is assumed to begin, the sexual life of woman continues, until coincident with the cessation of menstruation, ovulation also ceases. The total duration of this period in woman's life is usually about thirty years, but it is, however, variable, and would seem to run from as low as this to as high as forty-six years. According to statistics these variations depend upon climate, race, constitution, and other conditions of the person under consideration.

In order to understand the development of the egg-cell (or ovulation) we must get some other notion of the microscopic structure of the ovary. The main mass of the ovary consists of

Figure 4.



A section of a Mammalian ovary, magnified 1, outer capsule of ovary, 2, 3, 3' stroma, 4, blood-vessels, 5, rudimentary Graafian follicles, 6, 7, 8, follicles beginning to inlarge and mature; 9, a nearly ripe follicle, a, membrana granulosa, b, discus proligerus, c, ovum, with d, germinal vesicle, and e, germinal spot The cavity of the follicle is filled with lymph

Redrawn from Martin
Eula Wood

a dense mass of connective tissue containing unstriped muscle fibers, blood vessels, and nerves. It is covered by a peculiar layer called the germinal epithelium, which means the tissue in which the egg cells develop. Deeply embedded in the structure of the ovary are many small cavities containing ova, and called the Graafian Follicles. (See Fig. 4.)

If a thin section of an ovary is studied under a microscope it will present somewhat the appearance of the illustration. (Fig. 4.) Near the surface will be a layer (the germinal epithelium) in which many hundreds of Graafian follicles, each about one one-hundredth of an inch in diameter, will be embedded. Each of these follicles is lined by cells and contains a single ovum. In a woman capable of bearing children, there will be found also, deeper in, larger follicles, the cavities of which are distended by the liquid which fills them, (9. Fig. 4), so that the essential structure of the follicle can be plainly seen. It must be remembered that each of these follicles is a somewhat egg-shaped space in the ovarian tissue, muscle-fibers, etc., of the ovary. Inside it is lined by several layers of granular cells. These cells are heaped up at one end to form a sphere which encloses the ovum: nourishment is supplied to the ovum by the cells about it. As development goes on the Graafian follicle surrounding the ovum becomes greatly enlarged, while the ovum increases very slightly, so that proportionately the ovum and the cells about it come to occupy less and less of the space inside the follicle, the remainder being filled with liquid. A fully formed ovum is about one one-hundred-twentieth of an inch in diameter. Inside these narrow limits it shows, when sufficiently magnified, several different structures. There is first a distinctly marked outer layer, or coat, of radiating lines, inside that is the cell-body in which there is a large nucleus—with a germinal spot where growth begins. Small as the egg cell is, the main bulk of the cell-body is food material; what protoplasm there is lies close about the nucleus. The importance of the nucleus lies in the fact that the processes of cell division take place in it, and that here the new life, called the embryo, is formed. In the higher mammals, or animals most nearly resembling man in development, the food material is relatively slight in amount and is scattered through the protoplasm, and not only the nucleus, but the whole ovum divides to form the first cells of the embryo.

From time to time, usually about four weeks in menstruating women, certain ova, after attaining the size and structure which have been described, go through definite changes preparatory to fertilization. The changes are known as the maturing of the ovum, and will be discussed under the head of maturation farther on.

CHAPTER IV.

MENSTRUATION.

The process of ovulation ordinarily occurs at intervals of about four weeks during the reproductive period of a healthy woman. It is accompanied by important changes in the reproductive organs. The ovaries and Fallopian tubes become filled with blood, and the fringed edges of the tubes are erected and come into contact with the ovary in such a position as to receive any ova discharged. Whether they surround the ovary and so catch the ovum, or whether they merely touch it at various points and the ova are swept along by the minute hairs into the cavity of the oviduct (Fallopian tube) is not certain. When it has entered the oviduct the ovum passes slowly along it to the uterus, probably moved by the hairs, its passage taking four or five days. Fertilization probably takes place during this period, the sperm cell working its way upward into the oviduct from the uterus by means of its movable tail. If the ovum is not fertilized it dies and passes off.

Menstruation is a term used to characterize the discharge of bloody fluid which takes place from the uterus at stated periods throughout the time of sexual activity in the life of woman. An understanding of the true nature of menstruation presents certain peculiar difficulties, arising from the fact that menstruation is confined to human beings and some of the higher apes, so that the method of investigation usual in physiological research, namely animal experimentation, cannot be employed. Various theories have been proposed, to account for the phenomena of menstruation. One of these is that it is dependent upon ovulation, and coincident with it. According to this, the Graafian follicle by the swelling during its development, excites nerve impulses which, passing to the spinal cord, are reflected upon the nerves of the blood vessels, thus giving rise to congestion.

An entirely opposite view maintains that ovulation and menstruation are entirely independent functions. It is possible, however, to reconcile the two conflicting views by the supposition that although menstruation is not dependent upon ovulation, some relation exists between them by which they are, as a rule, coincident.

The mechanism of menstruation is much better understood than its cause. First: in the mucous lining of the uterus, there occurs a congestion of the numerous capillaries which finally become greatly distended so that blood transudes into the spaces between the cells which thus become enlarged. Second: the cells of the thin lining of the uterus seem to be pushed apart, when the tissue within is filled with blood, so that the blood escapes into the uterus through these spaces. Some of these cells are carried with the blood as it forces its way out. There is also some sloughing away of the cells in the layer beneath this. Third: last of all there is a return to the normal or usual conditions, and the blood vessels and tissues assume their ordinary appearance.

At the beginning of menstruation, the flow is of mucus, streaked with blood, but later the discharge consists of pure blood, mixed with a little mucus and epithelial cells from the uterus. Towards the end of the flow, it again returns to its mucus character. Menstrual blood is dark in color, alkaline in reaction, and owing to the presence of mucus it does not coagulate unless it is excessive in amount.

The age at which menstruation first takes place is given by different authorities at from twelve to fifteen. Cases are, however, sometimes found in which it occurs below or above the extremes of these averages without being in the slightest degree abnormal.

A series of twelve thousand five hundred observations, made from northern Canada to New Orleans, and over the whole continent from east to west, gives fourteen and three-tenths years for the laboring class, and fourteen and two-tenths years for the educated class. There seems to be very little difference between girls of American and foreign parentage.

A certain hereditary predisposition somewhat determines the age of the first menstruation. From a knowledge of the age at which menstruation began in the mother, we are able, with great probability, to predict the age at which it will begin in the daughter. An illustration of this is a mother who began to menstruate at the age of eleven, and whose eight daughters all began menstruation at the same age. The opinion is general, that girls with black hair, dark eyes, thick skin, and dark complexion begin to menstruate earlier than blondes with blue eyes and delicate white skins. There exists a wide difference in this age in different countries. For example, it does not occur until eighteen in the girls of Lapland, but appears at nine or ten in the aborigines of Australia and in the natives of southern Prussia, Egypt, Servia and Sierra Leone. For years it has been customary to explain the difference by the effect of climate hastening the coming of puberty in the warm regions, or deferring it in the colder regions. While this, doubtless, has something to do with it, it would seem that race also enters in, as for example, the Eskimo of Alaska, where in the cold climate menstruation begins at thirteen. It is well known, also, that in Jewesses menstruation begins at an early age. The duration varies also in different persons. When once the individual standard is established, however, it should remain fixed. The limits assigned by physicians are twenty-four hours to eight days, with most women four to six days. The amount of blood lost at each period is, however, difficult to estimate. Different authorities say from two to eight ounces (or 60 to 240 cc.). After the first few periods this, like the duration of the periods, will become fixed, and thereafter ought not to vary greatly. There is a very wide variation in the intervals. From time immemorial twenty-eight days has been accepted as the standard fixed by nature. Doubtless this was the reason why uncivilized peoples believed that it depended upon the periodicity of the moon. It may, however, occur at intervals varying from twenty-one to thirty-five days, and still be perfectly normal and the individual healthy. Strict adherence to individual habit in this is not so closely associated with health as is the duration of the flow or its amount, and even after regularity is established, variations of a day or two are very frequent, and without bad effects. In the temperate zone the sexual life of woman lasts longer than in the colder and sub-Arctic regions. Still more favorable is the contrast between the temperate zone and the countries of the tropics, in which the duration of sexual activity is limited to eighteen or twenty years.

According to some isolated observations, the duration of sexual activity in Arabian women in Africa is as little as nine years.

A certain influence on the duration of sexual life is exercised by the commencement of menstruation at an earlier or later age than the average. Duration of menstrual activity is more variable in women who begin to menstruate late. In those women who begin to menstruate early, duration of sexual life is about thirty-three years. In those who begin to menstruate late it is about twenty-seven years.

HYGIENE.

The periods of the menstrual flow in healthy girls require no marked deviation from normal hygienic habits. A day of rest is an excellent thing for a girl who suffers, or is nervous, or in other ways feels ill effects. Great care should be paid to cleanliness of person and clothing, as against the idea that is sometimes advanced that one should not bathe or change her underwear at such a time. The daily bath need not be intermitted. It is wise to replace a cold plunge with a cold sponge bath if you have been accustomed to cold baths. Do not attempt to take cold baths if you experience the slightest discomfort from them. The ordinary warm bath is probably the best in almost every case, unless a hot sitz bath is to be employed because of pain. Questions are sometimes asked about the diet. Whatever is suitable for a girl to eat at any other time is perfectly suitable then. This means simple, unstimulating food. Excessive exercise should be avoided. Long walks, the exertion of dancing, of repeated climbing of stairs, all tend to reduce the vitality. Many women habitually take the same exercise as usual. Teachers of physical training, in good health, rarely find their work interfered with. It seems probable that this is because the periods have become fixed, and with young girls it is likely to be rather injudicious.

CHAPTER V.

THE BEGINNINGS OF LIFE.

Biology has never revealed a more interesting story than that of the beginnings of life. The creation of an individual by the union of two tiny cells, and the subsequent growth of a human being from this fertilized egg by the division of a single cell, to form the millions of cells which make the body, has no parallel anywhere. We shall follow as simply as possible, the story of this union and development.

CHROMATIN.

The cells in the Graafian follicles of the ovary, which are to form the eggs from which a new organism will develop, are composed of protoplasm enclosed in a cell-wall and containing a nucleus. The substance of which all nuclei are composed, stains very deeply when colored so that it may be examined under a microscope, and because of this has been called chromatin (chrome = color). While the cell is growing this color is diffused through the nucleus in little irregular masses which form a sort of network. Before the cell divides, which is the way all cells increase in numbers, the chromatin takes the form of a thread and then breaks up into a number of V-shaped pieces. These are called chromosomes. The number of these chromosomes varies with the species of plant or animal, but in the same species it is always the same. In the rat, the pine, and the onion, the number is sixteen. In man there are thought to be forty-eight chromosomes. In some worms the number is as low as four, and in some small crustaceans as high as one hundred sixty-eight chromosomes.

MATURATION OF THE OVUM.

In every one of the higher animals there is a union of egg cell and sperm cell before the fertilized egg develops. Just previous to this union the egg goes through a process of maturation, the nucleus approaches the surface of the egg and divides into two parts each containing half the chromosomes. One of these parts is now pushed out of the egg, the other part remaining inside. After a short period of rest the division is repeated, and half the remaining chromosomes are expelled. The parts

Fig 5.

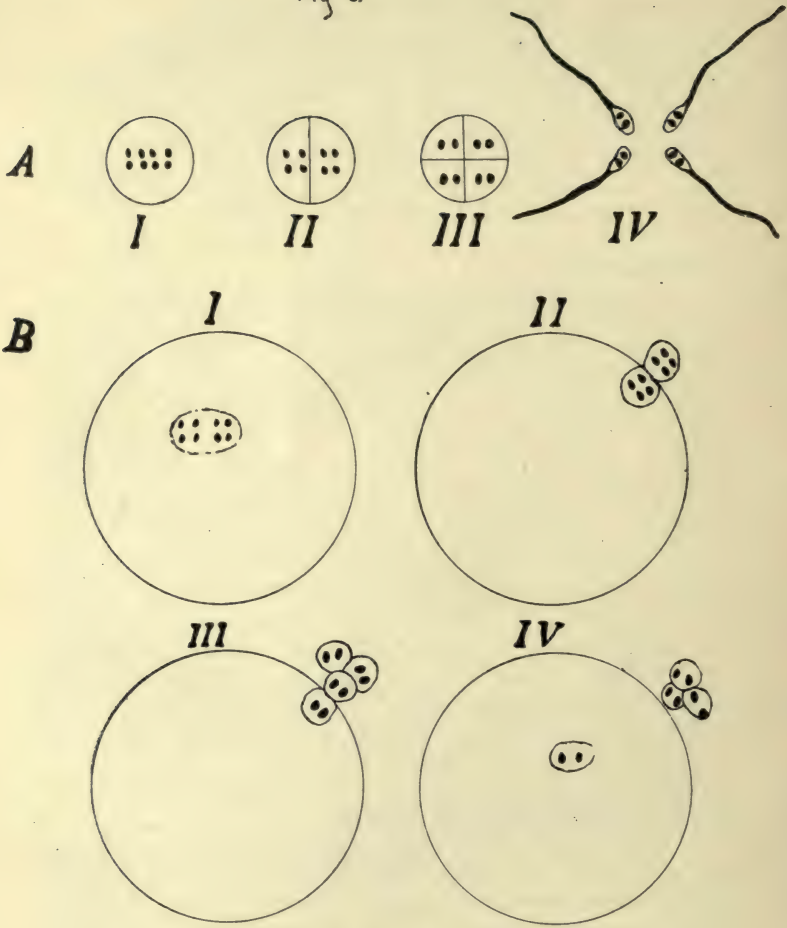


Diagram Showing a Comparison Between the Maturation of an egg, B, and the formation of the Sperms, A

Stages I to IV in series A and B correspond with each other.

W.J.S

of the nucleus known as polar cells which are expelled from the egg have no further value, since they take no part in the formation of the new individual. If this were not true, and the egg retained all its own chromosomes, and in fertilization received another complement from the sperm cell, the number of chromosomes would soon become so great that they could not all be carried in the egg nucleus.

THE SPERM CELL.

The sperm cell is only about one three-hundredth of an inch in length. As seen under the high power of a microscope, it is composed of two parts, the head and the tail. The head is flat and oval and behind this is the slender tapering tail which gives to the sperm cell its ability to move. Its rate of movement has been estimated at about one-eighth of an inch per minute. The sperm cell is formed in a special gland, the spermary, and makes its way to the surface through long complicated tubes. At the stage in the growth of a sperm cell which corresponds to the formation of polar cells in the egg, the sperm mother-cell divides into four sperm cells, each carrying one-quarter of the chromosomes and so corresponding in number with those of the egg cell. (See Fig. 5). So far as nuclear material is concerned, therefore, a sperm cell is to be regarded as equivalent to the matured ovum. At the end of the period of growth both egg and sperm contain half the normal number of chromosomes. The study of egg and sperm cells brings the conclusion that they are essentially equivalent, though differing somewhat in function. The egg is large compared to the sperm; the egg is quiescent and the sperm motile; besides its nucleus and protoplasm the egg carries a small amount of food material, while the sperm has a head which is mainly nucleus, and finally loses its tail which represents the protoplasm of the cell. All of these differences are secondary features, and in the essential character, which is the number of chromosomes, the two are similar.

When the sperm cells of any animal are fully grown they are passed through tubes to the exterior. In many cases as in the fish and frogs they meet the egg cells in the water, but where this is not the case they are excreted with a quantity of fluid in which they swim about with their motile tails. In all

Fig b.
Fertilization of the Ovum by the Spermatozoid.

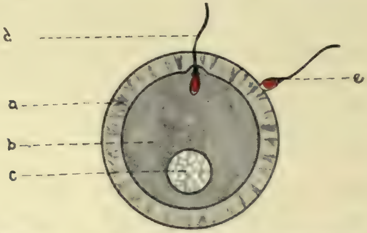
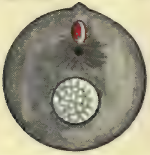
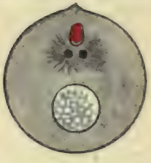


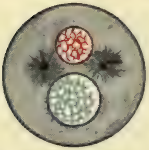
Diagram of the Ovum and Spermatozoid.
a Vitelline membrane; b. protoplasm or vitellus; c. nucleus with chromatin; d. Spermatozoid penetrating egg; e. another spermatozoid arrested by the vitelline membran



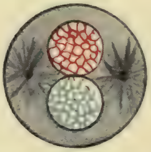
Formation of Centrosome



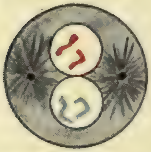
Formation of male nucleus by Spermatozoid. Division of Centrosome



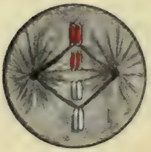
Development of Nucleus of Spermatozoid



Nucleus of Spermatozoid attains same size as that of Ovum



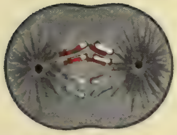
Formation of male and female chromosomes



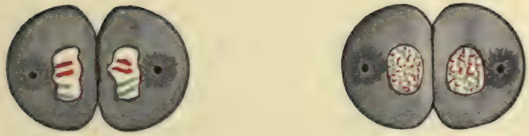
Lining up of male and female chromosomes.

Altered from Forel, by
W.J.S

Fig 7.



Attraction of Chromosomes
by centrosomes.



Concentration of nuclei
Division of cell.

Formation of new
chromatin.

Altered from Forel, By.

W.J.S
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the higher animals they are placed by the male in a sac in the female's body which is prepared to receive them. Their actively moving tails drive them into the passage containing the eggs, and when the egg and sperm cell come into the same vicinity they exercise an attraction for each other, come together, and the sperm cell finally buries its head in the egg cell.

FERTILIZATION.

As soon as a sperm cell touches an egg it penetrates it, and coagulation takes place on the outside which prevents the entrance of other sperm cells. Just in front of the head of the sperm cell appears the centrosome, a tiny spot from which there are radiating lines. Presently the centrosome divides into two parts which move slowly toward the periphery of the egg on each side; between these the chromosomes of egg and sperm cell arrange themselves and divide crosswise so that there become finally twice the original number. The chromosomes then separate in such a manner that each half of the cell is equally supplied with chromatin material from egg and sperm cell, and when this occurs the egg divides into two cells, which is the beginning of growth. Each of the two cells first formed contains the same quantity of paternal as maternal chromatin. As cell division continues in the same way throughout growth it follows that each cell, or at least each nucleus of the future organism, will contain on the average, half its substance from the maternal and half from the paternal side. (See Figs. 6 and 7).

DEVELOPMENT.

When the fertilized egg descends from the Fallopian tube to the uterus it forms, after a little, a ciliated mass. This attaches itself to the soft wall of the uterus, and begins to embed itself in the mucous membrane lining the organ. Presently it is entirely covered over in this mucous lining, which before the egg reached it was only about one-eighth of an inch in thickness, but now increases to one-half an inch. The egg now comes to lie in a tiny cavity in the mucous membrane, where it is surrounded by blood in which it is bathed and from which it secures its nourishment by osmosis. As pregnancy advances and the embryo grows, it bulges out into the uterine cavity, and by the third month of its growth it entirely fills the uterine cavity.

Meanwhile the uterus enlarges and the muscular coat becomes very much thicker. At first the organ still lies within the pelvis. Later on it escapes higher into the abdominal cavity.

THE PLACENTA.

In the beginning the embryo is fed by osmosis from the blood vessels in the mucous membrane which surrounds it. As it increases in size this supply does not keep pace with its growth, and a new organ, the placenta, is formed. The tiny outgrowths by which the mass was first attached to the uterus, grow into the tissue of the uterus around them. In the deeper layers of this mucous membrane are large blood spaces through which the blood of the mother flows and into which these outgrowths, or villi, from the embryo project. In the final stages of the placenta, blood is brought from the embryo to these villi by arteries and carried back by veins after passing through the capillaries of the villi. It is while the blood is passing through the villi that it receives by osmosis oxygen and food materials from the maternal blood, and returns to it carbon dioxide, urea, and other wastes. There is, therefore, no direct intermixture of the blood of the embryo and the mother; the embryo is, from the first, an essentially separate and independent organism. The outgrowths from the embryo and the uterus become united together in the placenta, which, in the human species, when fully developed is a round thick mass about the size of a saucer, connected with the embryo by a mass of blood vessels, the umbilical cord, in which the blood passes to and from the embryo.

GROWTH OF THE EMBRYO.

The different stages in the development of any mammalian embryo are very interesting and curious. Within its protecting layers the egg cell at once divides, first into two cells, then four, eight, sixteen, etc. Only a thin plate of cells is formed at one side of the egg, which is now a spherical ball of cells. Then this plate of cells begins to form a slight furrow, one end of which is a little larger than the other. This end will eventually be the head and when the folds at the edge of the groove unite they form the neural canal which contains the spinal cord, and at the head end the brain is formed. At first all the cells appear to be similar, but, as development goes on, they begin to differentiate themselves into different kinds, some forming the actual nerve cells of brain and spinal cord, others developing into protective structures.

The posterior part of this canal which gives rise to the spinal cord is very much narrower, and presently a number of constrictions appear at intervals along it. A little later the pairs of spinal nerves arise from these constrictions. In the beginning of embryonic life the spinal cord is the same length as the canal, but in time the canal lengthens out, so the nerves at the posterior end grow longer than the others. At the anterior or head end, two very marked constrictions appear, and form three distinct parts of the brain area. The posterior of these gives rise to the spinal bulb and cerebellum. The central one forms a less important part called the mid-brain, which serves to connect the parts just named with the most important anterior part. From the anterior is developed the cerebrum and the senses of sight, hearing and smell. The anterior end buds off on each side to form two distinct parts which growing rapidly, push back over the remainder of the brain to form the halves of the cerebrum. In the outer layers appear the gray cells of the cerebrum, so that brain tissue is born and not made, since its amount is determined before birth. It is the manner of its after use which decides whether any given brain reaches its highest development.

At about the fourth week there appears on the under surface of the cerebral hemispheres, toward the front, a prolongation which becomes the olfactory lobes from which come the nerves of smell.

The brains of the higher vertebrates show on the surface a number of folds which we call convolutions, and comparisons show that the more convolutions in the adult brain, the higher the animal concerned from the standpoint of brain power. In the human embryo these convolutions do not begin to appear until about the fifth month, at which stage the brain is relatively large.

From the front part of the anterior enlargement of the three which form the brain, there early appears a pair of hollow outgrowths which grow until they reach the outermost layer of cells, the ectoderm, which will form the skin. Here these processes turn in so as to form a double-walled cup, the inner layer of which develops the retina of the eye. From the retina, cells grow in to form the optic nerve. Then the ectoderm cells thicken over the retina to form the lens of the eye. Later another layer of cells forms the cornea, in front of the lens.

At the same time that the nervous system is developing the body of the embryo is also forming. Early in its formation the body is represented by an incomplete tube, the incomplete part being the ventral side of the body wall. In time this becomes completely closed except at one point. This point is at first the place where the inside of the embryo connects with the yolk sac, which is a cavity enclosed by cells which develop inside the egg. As growth goes on a part of this yolk sac is included in the embryo itself where it becomes the alimentary system. The remainder of the yolk sac ultimately becomes a part of the cord which joins mother and child.

The origin of the heart is a curious part of the development. It forms in the first place as two halves of a tube, one on each side of the ventral side of the body; as the sides of the body grow together these two halves unite to form a tube, which presently comes to be bent upon itself in the form of the letter S. One end of this now enlarges, forms a pouch on each side, and becomes two auricles. From these auricles a partition grows vertically and except for a little opening in the upper part, cuts them off from each other. This little opening closes after birth, when blood passes to the lungs, and so no longer from one side of the heart to the other to be sent around the body. Another wall shuts the ventricles from the auricles, and the ventricles in their turn are separated by a partition. In this way a four-chambered heart is formed from a simple tube.

As the ventral side of the body of the embryo closes over, the mouth and nose are formed by folds which come together in the middle line. If one of the folds does not properly unite with its neighbor, such a deformity as hare-lip may occur.

If the growth of the embryo runs a normal course, the following points could be seen at various stages. At the end of the fourth week the embryo is distinctly curved, so that the two ends, the head and tail, are close together, the whole being about one-half inch long. At this stage the brain and spinal cord are closed in. The vesicles of eye and ear have made their appearance ,and the legs and arms show as buds. The heart is already beginning to show four chambers. In another month the embryo is an inch long, and begins to look more like a human being. The tail has disappeared. Hands and feet show, eyes and ears are formed, the nose can be recognized. At the end of the twelfth week the embryo is about three and a half inches long. The head now appears very large. At the twenty-fourth week hair grows on the head. In twenty-eight weeks the embryo weighs about two and one-half pounds. Another month, and its weight has increased a pound. In the next four weeks it gains two pounds, weighs about five and one-half pounds, and is about eighteen inches long and the body is somewhat filled out by fat. Finally, at the end of forty weeks the normal healthy child should weigh seven pounds and be twenty or twenty-one inches long. At this time like a ripe seed in a plant, the placenta begins to separate from the uterus, and the child is expelled from the body through the birth canal or vagina. Henceforth development is a matter of environment.

CHAPTER VI.

SOCIAL STANDARDS.

The standards that form a common measure of conduct between men and women are set by the women. In no less degree the standards held by the boy are set by the girl. A boy's ideas and ideals of women are determined between the years of fifteen and twenty-one, and the girls he associates with are forming them. A girl often does not realize what a force she is, or may become, in her influence with her boy chums.

The girl whose standards of honesty are high, who is considerate and unselfish, who enjoys wholesome, open fun, is already doing a great service to society in unconsciously creating a desire for the things she represents. A boy's estimate of girls in general is apt to be based on the girl he first knows intimately. Without thinking of it he measures other girls by her, and that often determines his friendships.

The boy whose home training is right, and who has all his life associated with good women and girls, has ideas of them which later life is not likely to alter.

Unfortunately, not all the men a girl comes in contact with either in business or social life are of this type. If she respects herself she will be respected in most cases. The girl whose dress or conduct make her conspicuous in public places is at once singled out as the one to whom a man may offer familiarities, or make improper advances. If a girl allows such attentions, she is herself responsible for the results. She must realize also, that as soon as a man takes such advantage of her, he no longer considers her of his class. She has lost caste even in the eyes of the man who professed to care for her. A girl must remember, also, that her conduct reflects upon her home training, and that her mother suffers for her mistakes quite as much as she does. She is held responsible, in the eyes of society, if her daughter does wrong. "What is her mother thinking about to allow it," is a common criticism when a girl's conduct is under discussion.

When girls look upon love and motherhood as something high and sacred, to be reverenced, never to be debased by flippant words or familiarities of speech and action, then the qualities of humanity will be improved by intelligent parentage. Suppose all the women of this country for the next thousand years should consider this their highest happiness, to promote the best interests of humanity. What dreams of our nation might not be realized!

Girls sometimes say when their physical limitations hamper them, "I wish I were a boy," but that is missing what it means to be a girl. The good in a country depends absolutely and entirely upon the character of its women. If they are self-indulgent one can not expect much of the people. To do service for her country, the girl must become a woman with a vision of what motherhood may mean. If actual motherhood may be denied her, the power to suffer for others, the will to sacrifice, may still be hers.

Motherliness was the first germ of altruism. The animal mother protects her young. In the human being the animal instinct has become sympathy, compassion for suffering, helpfulness, and in the end, duty. What motherhood has cost in constant giving, only the mothers of all the ages could tell. It is to their mothers that great sons have borne witness, that to them they owe their own essential qualities.

If marriage and motherhood are not within the reach of every girl, it is essential that every girl should see that physical motherhood is not the whole of human motherhood. It is a woman's prerogative that she may realize herself and serve others in distinctively feminine lines.

Such a woman as Florence Nightingale was the foster mother of countless thousands. It is the motherliness of Jane Addams which has given her so rare and beautiful a love for humanity that Hull House has become a neighborhood home. It is the motherliness of Dr. Catherine B. Davis which has made her, in the prison she supervises, the mother of new souls, born again in an effort to achieve a womanhood they had never before known.

Whether or not she consciously recognizes it, maturity brings to every girl the instinct of motherhood. It is the highest instinct of human life, and as such it is neither a feeling to be ashamed of, nor to allow to become ungovernable. Like other changes which come with growth, it is to be accepted and realized, when it may be, in marriage. The ignorant girl, or the girl who thoughtlessly yields to it, becomes henceforth the "girl in the shadow." Many girls do not realize that the sin of such illicit sexual indulgence will go any farther. It almost inevitably results in impregnation which means that in time, however unwillingly, the girl will become a mother.

The standards of present day society make no place for the unmarried mother. In the eyes of the world she has committed an unpardonable sin. When one considers the evil and sorrow that follow the trail of the girl who has gone astray, it renders more emphatic the old saying, "A good name is more to be desired than great riches."

There were three thousand one hundred ninety-five births in Grand Rapids in twelve months, and of these one hundred fifty-nine were illegitimate. This means an equal number of girl mothers who lose—in most cases—friends and home, and of children who cannot claim a father's name. The illegitimate child, hated before its birth, and unhappy in a scheme of things which provides no place for it, often returns this hatred to the world at large.

It is true that the girl mother and her illegitimate child suffer far more heavily than the man who is responsible. Time and custom have established a double standard of morality. In defence of this it has been claimed in the past that it was necessary for the man. The better class of men today are as clean morally, as good women; and more and more it is being recognized that it is not needed by the man and not fair to the woman. A good man takes as much pride in a clean body as a good woman, and has as little need of sowing wild oats. Neither man nor woman may sow immorality and reap health and happiness. The man who indulges in illicit sexual connections finds it results in disease and suffering, and if he is married his wife and children suffer with him.

Nature's punishment for immorality comes in part in the form of germ diseases commonly called venereal diseases. No man who even occasionally indulges in immoralities may hope to escape some one of these diseases. No girl who marries a man afflicted with such a disease can prevent the disease passing on to herself and her children.

In the case of syphilis the germ may be carried by the blood to all parts of the body, and every organ and tissue may be affected by it, or open sores may result. It is also the cause of a large amount of insanity. Not only does the man transmit this disease to his wife, but it is hereditary also, and may affect the third generation. His children may directly inherit it; the death rate among syphilitic babies ranges from sixty to eighty-five per cent. Those children who grow up are affected in mind and body. Like other germ diseases it may be innocently acquired through the medium of an infected drinking cup, or by handling objects infected by a syphilitic person.

The cure of syphilis is very difficult and slow, and it is almost impossible to be certain that a cure has been effected.

The other common venereal disease is gonorrhoea. Here there is inflammation and destruction of the reproductive organs. Dr. Victor Vaughan, of Ann Arbor, states that a very large number of the abdominal operations on women come as a result of this disease. When the mother has gonorrhoea the germs often get into the eyes of children at birth, and twenty per cent of all blindness is estimated to be due to this cause. The woman who has gonorrhoea is likely to become sterile, and thus bears no children after such infection. It is unfair to the girl to ask her to run the risk of acquiring such diseases, and it is an injustice to innocent children to bring them into the world diseased at birth, in mind and body.

No community can ever rise above the level of the families which make it up. Our social and political fabric is built on the unit of the home, and the man and woman who form this home should bring into it equally physical and moral health. Every child is entitled to the birthright of a clean and wholesome physical and mental outfit.

CHAPTER VII.

HEREDITY.

The Meaning of Chromatin.

Each individual is the son or daughter of what his father or mother ought to have been. His characters are drawn from his parents' possibilities, not from what these people were, still less from what they appeared to be. The process of fertilization shows that the only contribution always made by each parent to the egg is the chromatin or nuclear material. Therefore, since each parent does contribute chromatin in equal amounts, here must lie the secret of heredity.

It is a curious and wonderful thing that in so small a compass as the nucleus of an egg, which is itself only one one-hundred-twentieth of an inch in diameter, so great a number of characters may be transmitted. Truly "a frail bridge to carry so heavy a traffic," but here is the only physical basis of inheritance, and here, therefore, the factors of heredity must be.

Since this process of egg cell formation is universal among higher plants and animals it must be of great significance, and at least one reason for its importance lies in the fact that the union of egg and sperm cell provides for two lines of inheritance. If the individual developed wholly from a cell furnished by one parent, there would be opportunity for resemblance to that parent only, but the mingling of two sets of chromosomes provides for variation from parental types, and so offers a chance for development.

The gates of heredity close for each of us when the egg is fertilized. What we are is then decided. It remains to see what we have, and what we do. Here is where environment comes to the aid of heredity. For example, the child brings into the world with it all the brain cells it is to have. The use that is made of these, and the connections established between them, determine what kind of mental activity the child will be able to carry on. This is the point where education enters in, and probably education in some sense never ceases so long as we are consciously alive.

The Continuity of Germ Plasm.

The germ cells which produce new individuals are themselves produced from pre-existing germ cells. The entire embryo is derived from one single cell which we have called the fertilized egg, and that in turn was derived from the union of two germ cells, one from each parent. These two cells in their turn were directly derived in a straight line of descent from the fertilized ovum from which each parent sprang.

The body cells contribute nothing to the original material or germ plasm of which germ cells are composed. They do not produce germ cells in any sense of the word. Hereditary influence preserves all its primary power and original qualities in the chromosomes which enlarge and divide. The cell substance, absorbed by the chromosomes and changed by chemical processes into the substance of which they are composed, acts as does the food which we swallow, losing its energy in the process of building tissue. A person does not become like the ox by eating beefsteak, and the chromosomes in the process of growth preserve unchanged all their hereditary characteristics.

Thus, there results a continuous stream of germ plasm, which receives contributions from other streams when the egg is fertilized. Father and son owe their resemblance to the fact, that they are "chips of the same block," i. e., both are products of the same continuous stream of germ plasm, at successive intervals; the son having in addition a maternal contribution of protoplasm which may modify the other. From the point of view of heredity, therefore, the function of the body cells is to store, temporarily, this undying germ plasm. The parent is only the "trustee of the germ cell," not the producer of the offspring. Furthermore, since one generation of germ cells directly produces the next, there is no reason why a child might not more closely resemble a remote ancestor than his immediate parent. He does so because the germ cell from which he developed, is composed of protoplasm handed down in direct continuity by successive generations of germ cells from time immemorial.

In this way the nuclear chromatin of our germinal cells becomes the carrier of all hereditary qualities of our parentage, more especially those of our direct ancestors. In this we find the reason why different children in the same family are so unlike. It has been said that the egg loses some chromosomes as it develops. If the egg cell loses the chromosomes which transmit certain qualities before the egg nucleus unites with the sperm nucleus, those qualities will not develop in the child. It is thought that similar twins develop from a single egg and that is why their characteristics are the same. Dissimilar twins apparently develop, on the other hand, by the fertilization of two eggs at about the same time.

Heredity results from the fact that offspring are material continuations of their parents, consequently may be expected to resemble them. Just as evident as heredity, however, is variation, e. g., blue-eyed children come of brown-eyed parents. Breeders of plants and animals constantly find that they will not "breed true."

It is a fortunate thing for the breeder, as for the human race, that variation exists. Otherwise every generation would be at a dead level, and there would be no such thing as advancement.

Laws of Inheritance in Use.

In the year 1900, the National Association of British Millers employed a scientist to study the wheat production of that country to see whether the character and amount of the crop could be improved. The scientist, Dr. Biffen, sent all over the world for samples of wheat, each of which had some one good quality. One had a stout stalk, another a heavy head, another was beardless and one was immune to the wheat rust. Dr. Biffen planted and mated these according to the results he wished to produce. So sure are these laws that, by means of them, in a few years he was able to turn over to the association which had employed him, an entirely new wheat. It has a strong stalk, a full head, and it is beardless. It even resembles another of its ancestors in being immune to rust. This artificially produced variety has been pronounced a great success. This is not the only illustration of such use of the laws of inheritance. Stock breeders and plant breeders everywhere, regard them as a commercial asset. Cattle and sheep, fruits like the plumcot, flowers like the Shasta daisy, and

Fig 8.

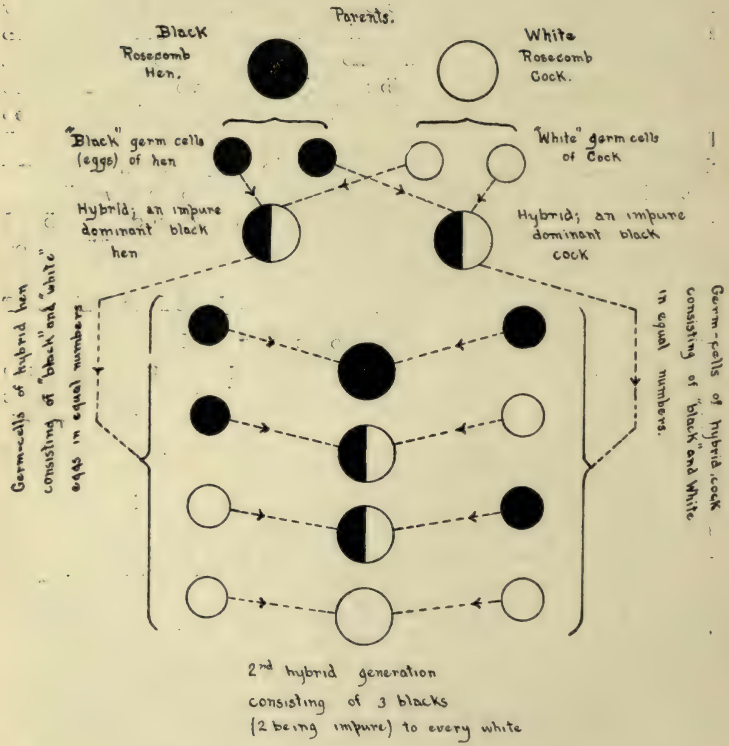

Parents.
Black Rosecomb Hen.
White Rosecomb Cock.
"Black" germ cells (eggs) of hen
"White" germ cells of Cock
Hybrid; an impure dominant black hen
Hybrid; an impure dominant black cock
Germcells of hybrid hen consisting of "black" and "white" eggs in equal numbers
Germ-cells of hybrid cock consisting of "black" and White in equal numbers.
2nd hybrid generation consisting of 3 blacks (2 being impure) to every white

Diagram illustrating the inheritance of the Black and White characters in Rose-Comb Bantams

Redrawn from
Punnett, by
WJS

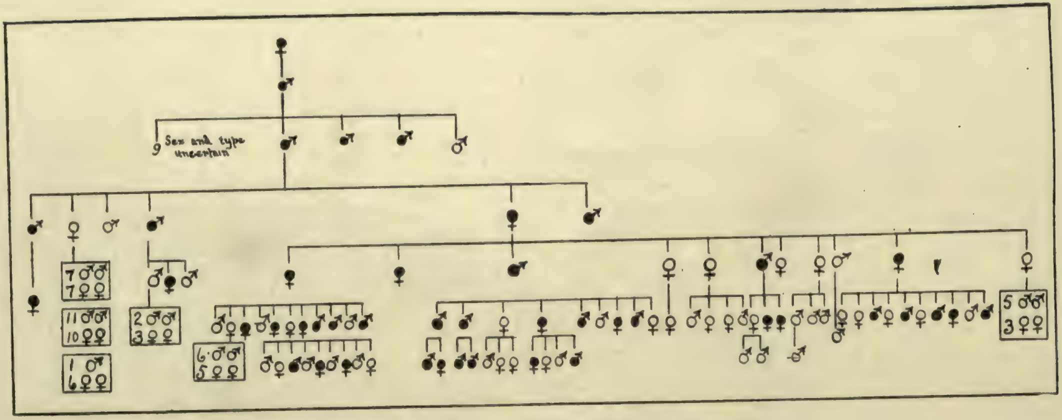
even a spineless cactus, and a quick growing black walnut tree, show how this knowledge has been put to use. The story of how we come to know these laws is a fascinating chapter of recent science.

Gregor Mendel.

Few subjects touch man so closely as heredity, yet upon few is there more widespread ignorance. The complexity of the problems and the difficulty of getting at them discouraged scientists, and yet the work of studying heredity has passed from theory to actual demonstration in the work of one man. More than forty years ago Gregor Mendel, an Austrian monk, made the first experiment by the scientific method of observation and experiment, in the study of heredity. Mendel's paper remained forgotten until the beginning of the present century. Since then his experiments have been confirmed over and over again. For illustration, let us take the case of rose comb bantams. These are of two kinds, black and white, and true strains of either color breed true to their kind. If, on the other hand, the black is crossed with the white, the offspring are like the black parent. For this reason black is said to be dominant to white, which is called recessive. When, however, these black bantams of the second generation are bred together they produce both black and white, in the proportion of three blacks to one white. If the whites of this generation are bred together they produce only whites, in spite of their black ancestry. There are two classes of the blacks; some pure dominants, in which, when blacks are mated with a white bird, only black progeny will be produced, and some impure black dominants which being mated together give both blacks and whites in the proportion of three to one. If such birds are crossed with whites, it can be shown by experiment that they will produce an equal number of blacks and whites. (See Fig. 8.)

Mendel's explanation of this was very simple, going back to the chromosomes which we found in the nucleus of the egg cell and sperm cell. In the case of the bantams we are dealing with two alternative characteristics, blackness and whiteness. Mendel's idea was, that a given germ cell could contain only one of these characteristics. Such characteristics,

Fig 9.



· Pedigree of a Brachydactylous Family

♂♀ Denote normal males, and normal females respectively. Similary, ●♂●♀ represent brachydactylous males and females. Every individual represented as having issue was married to a normal. It will be noticed (a) that an affected individual always has one affected parent, (b) that about one-half of the children of an affected parent are affected, while the rest are normal, (c) that the children of normals when married to normals are never affected, in spite of the family history.

Redrawn from
Punnett, by
W.J.S.

which are transmitted as separate units, are known as unit characters. In the present instance each germ cell produced must carry either black or white, but never both. When the black germ cell united with another black germ cell the result will be a pure dominant black chicken, which can produce only black germs. A white germ cell in the same way uniting with another germ cell would give rise to a white chicken producing only white germ cells. When the black germ meets a white germ the result is a black bird because black is dominant over white, but when this bird comes to form germ cells the black and white characteristics separate and pass singly into the cells. Mathematically, this can lead to but one result. Thus one quarter of the progeny will be formed by the union of two black germ cells, one-quarter by the union of two white germ cells, and two-quarters by the union of a black and white germ cell. These will look black because blackness is dominant to whiteness where both cells exist in the same individual. This makes the production of the blacks appear to be three blacks to one white. If the members of this family are bred together the whites breed true, in spite of the fact that their parents, and their brothers and sisters are black. They cannot breed black because none of them has any black germ cells. Of blacks there will be two groups, one of which will contain twice as many individuals as the other. These are the hybrid blacks formed by the union of a white and a black germ cell. When bred together, one-quarter of their offspring will be white. The other class of blacks consists of those formed by the union of two black germ cells. These breed pure black like their original black grandparents. This is the simplest form of Mendelian inheritance. During the past few years it has been demonstrated for such varied characteristics as structure, size, shape, color, and fertility among plants as well as certain characteristics among animals. In animals, the long angora hair is recessive to short hair in rabbits. Color is dominant to albinism in rabbits, rats, and mice. Chestnut is recessive to bay or brown in horses. In fowls, such characteristics have been demonstrated in the color of the plumage, the skin, and the form of the comb.

Mendel's Law.

These results may be simply stated in three great laws of inheritance.

1st. When pure-breds are mated with other pure-breds like themselves, every one of their offspring will be pure-bred. So long as mating is continued between pure-breds, their descendants will always be pure-bred.

2nd. When a pure-bred of one character is mated with a pure-bred of another character, every one of the offspring will be a hybrid.

3rd. When hybrids are mated one-half their offspring will be hybrid, one-quarter will be pure-bred like the father, and one-quarter pure-bred like the mother.

Application to Men.

Man, too, is subject to the same laws of heredity that govern the transmission of qualities of plants and animals. How these laws work in the history of families is shown in the inheritance of a peculiar condition known as short-fingeredness.

Short-fingeredness.

This is a malformation of the hands and feet so that the joints of fingers and toes have but two, instead of three parts, and the whole body is stunted. This condition is dominant to the normal state of fingers and toes. Where a normal person marries one who is short-fingered, this peculiarity is transmitted on the average, to one-half their children. It is an even chance whether a child will be affected or normal, but when a normal child appears it will never have any but normal offspring, no matter what the history of its family may have been.

Eye-Color.

Another interesting illustration of heredity in human beings is that of eye-color. The iris has on its inner surface a layer of dark purple pigment. In brown eyes there is an additional layer of yellow (and perhaps brown-red) pigment on its outer surface also, and sometimes there is pigment among the fibers. In the albino, pigment is entirely absent from both surfaces of the iris, and the bright red blood, seen through the semi-transparent tissue, makes the eyes apparently pink.

The eyes of all new-born babies are dark blue, the iris being then so delicate that the layer of pigment shows through very distinctly, as the tissues grow thicker by use and age the eyes become light blue or gray. If yellow pigment is laid down upon the blue, yellow-blue or green eyes are produced. In hazel or brown eyes the purple back of the iris and the fibers are hidden by deposits of yellow and brown pigment on the front of the iris, and when this is very dense, black eyes result. It has recently been shown that brown pigment is dominant when present. That is to say, if a person is the carrier of brown pigment, it will appear in the eyes. Blue-eyed children may, therefore, spring from brown-eyed parents, but a brown-eyed child from pure blue-eyed parents would be an anomaly.

"Bleeders."

We have some knowledge of the transmission of diseases. Among these is a condition characterized by a tendency to hemorrhage, and by difficulty in blood clotting, so that when a hemorrhage begins it is hard to stop. Such families are known as "bleeders." Fifty times as many males as females are affected. Generally as age advances the hemorrhages cease. The curious thing about the disease is that it is transmitted by normal females, whose fathers were bleeders, to their sons.

The Jukes Family.

Heredity is not confined to physical traits. Good and bad mental and moral traits may be perpetuated. Few families illustrate a bad heredity more successfully than the descendants of Max Juke, a shiftless, lazy, drunken fisherman, who was born in New York state in 1720. The man had five daughters. In five generations the family numbered twelve hundred persons, including about two hundred who married into it. Of these twelve hundred idle, ignorant, vicious, pauper, diseased, imbecile, insane, and criminal specimens of humanity about three hundred died in infancy. Of the remaining nine hundred, three hundred and ten were professional paupers in alm-houses a total of twenty-three hundred years; four hundred and forty were viciously diseased; more than half the women were prostitutes; one hundred and thirty were convicted criminals; sixty were habitual thieves; seven were murderers. Not one had even a common school education. Only twenty ever learned a trade, and ten of these learned it in state prison. They have cost the state over a million and a quarter dollars, and the costs are still rolling up. Why does society allow these unfortunates to be born into the kind of lives which are forced upon them not by choice, but by the misfortune of birth? Darwin wrote long ago, "except in the case of man himself, hardly anyone is so ignorant as to allow his worst animals to breed."

The Kallikak Family.

A very curious natural object lesson in heredity has recently been put in print. Just before the Revolutionary War a young man who lived in New Jersey, a descendant of a long line of good English ancestry, became the father of an illegitimate son, by a feeble-minded girl. The young man went into the army and became of some note. We will call his name Martin Kallikak. This, however, is not the true name. After the Revolutionary War was over Martin Kallikak married a Quaker girl of good ancestry and settled down to live a respectable life. After the fashion of his forefathers, doubtless, he disregarded his first born illegitimate son. Not so nature. Born of a feeble-minded mother, this boy proved to be feeble-minded also, but, however, married a normal woman. They in turn produced five feeble-minded and two normal children. Practically all the descendants of these defectives have been traced, as well as the descendants of Martin Kallikak's Quaker wife. We will give our attention first to the normal and defective descendants of the illegitimate son, four hundred and eighty have been traced. Of these thirty-six were illegitimate, thirty-three sexually immoral (mostly prostitutes), thirty-four confirmed alcoholics, three epileptics, eighty-two died in infancy, three were criminals, eight kept houses of ill-fame, and one hundred forty-three were distinctly feeble-minded. Only forty-six were found who were apparently normal. The rest are unknown or doubtful. The man who started this long line of delinquents and defectives has also an entirely different set of descendants from his legal marriage with the Quaker girl. There have been four hundred ninety-six descendants. All of these except two have been of normal mentality. The exceptions were cases of insanity, probably inherited because of marriage with outside stock in which there was constitutional insane tendency. In all of these four hundred ninety-six there is not an instance of feeble-mindedness. They have universally occupied positions in the upper walks of life. There have been no criminals or black sheep in this line. On the other hand, among the descendants of Martin Kallikak and the feeble-minded girl, there has not been one instance of exceptional ability and most of them have fallen far below even the level of mediocrity.

A family in Indiana known as the "tribe of Ishmael," have in five generations produced seventeen hundred fifty individuals. Of the women more than thirteen per cent are known prostitutes and most of the men are alcoholics and criminals, the charges against them varying from petty larceny to murder. In one county in Michigan there is a group of families connected by intermarriage, only five per cent of whom are normal. Miss McKinnie, who has been investigating for the State Board of Health, says that the total cost of maintenance for defective members of these families in state institutions has been over $86,000, exclusive of the capital invested in the buildings and of local or state aid given in their homes. From these families there were at one time thirty-eight in the home for the feeble-minded at Lapeer, one hundred thirteen feeble-minded at large, and twenty-two known prostitutes. Miss McKinnie estimates that there are no less than nine thousand feeble-minded at large in the state, and these are reproducing their kind. From among such people as these come our worst criminals, the Guiteaus and the Czolgoczs.

The Edwards Family.

Heredity has also a bright side, for the good in human germ plasm is as heritable as the bad. From two English parents, the father remotely descended from royalty, was born in Massachusetts in the middle of the seventeenth century, Elizabeth Tuttle. She married in 1667, Richard Edwards of Hartford, Conn. Their only son was Timothy Edwards who graduated from Harvard College in 1691, gaining simultaneously two degrees, A. B. and A. M. He was pastor of a church in East Windsor, Conn., for fifty-nine years. His only son was Jonathan Edwards, a great divine and theologian, president of Princeton College. A brief catalogue of his descendants gives many interesting names. Jonathan Edwards, Jr., president of Union College; Timothy Dwight, president of Yale; Sereno Edwards Dwight, president of Hamilton College; Theodore Dwight Woolsey, for twenty-five years president of Yale College; Sarah, wife of Tapping Reeve, founder of Litchfield Law School, herself no mean lawyer; Daniel Tyler, a general of the Civil War and founder of the iron industries of north Alabama; Timothy Dwight, the second, president of Yale University from 1886 to 1898; Theodore William Dwight, founder and for three years warden of Columbia Law School; Henrietta Frances, wife of Eli Whitney, inventor of the cotton gin, "who, burning the midnight oil by the side of her ingenious husband, helped him to his enduring fame;" Merrill Edward Gates, president of Amherst College; Catherine Maria Sedgwick, a writer; Charles Sedgwick Minot, professor of biology and embryology in the Harvard Medical School, and Winston Churchill, author of "Coniston." Two other descendants of Elizabeth Tuttle, both brilliant, but neither a moral leader, as have been those mentioned, were Pierrepont Edwards, a lawyer of distinction, and Aaron Burr, vice-president of the United States.

From the fourth daughter of this woman came notable descendants. These include Robert Treat Pain, signer of the Declaration of Independence; the Fairbanks brothers, manufacturers of scales at St. Johnsbury, Vt.; Morrison Waite, Chief Justice of the United States; Ulysses S. Grant, and Grover Cleveland, presidents of the United States. Many distinguished persons trace their origin, in part, to that strain of germ plasm from which Elizabeth Tuttle was derived, but of which she was not the author.

CHAPTER VIII.

EUGENICS.

"A good stock is the only material out of which history can make a great nation."

Everyone of us knows something about the breeding of animals and plants, but not many realize how much skill and care are necessary to make it a success. We call Luther Burbank a wizard, as though there were magic in his touch, but the magic lies instead in accuracy of eye to detect variations and judgment to make use of them. He has devoted his life to the effort, and has brought to it both skill and indomitable perseverance. Out of his efforts and those of men similarly engaged, has accumulated a vast store of information, used so far mainly to produce more desirable animals and plants, but equally applicable to human beings. The eugenist questions why all this should be applied to the improvement of pigs and cabbages, and not to the owners of the pigs and cabbages as well. Why should the pig be better bred than the man? We pay large sums for thoroughbred animals, and we desire the best fruits and vegetables; but we have not, so far, been very keen about demanding human thoroughbreds.

"The aim of eugenics," wrote Sir Francis Galton, "is the production of a more healthy and vigorous and more able humanity."

Each person is the product of two factors, heredity and environment. Which of these is more important, makes little difference. Both are necessary. A good harvest is the product equally of good seed and good soil.

We are attempting, at the present time, through the agency of the government both of the United States and of the individual states, and by means of public education in sanitation, to provide the present and coming generations with a better environment. Today, those who are interested in this movement are asking what kind of human beings are constantly being born to occupy this environment, and the inquiry is not confined to the United States, but is being made all over the civilized world. Dr. Saleeby, one of England's most famous eugenists, has declared, "I am of nothing more certain than that the choice for Great Britain today is between national eugenics and the fate of all her imperial predecessors from Babylon to Spain."

Those who are acquainted with statistics claim that the English nation is degenerating, although more attention is constantly being given to improvement in the conditions of living. German statistics, it is claimed, prove that the number of young men fit to enter the army constantly decreases. Scientists are beginning to say that both these nations are producing new generations from poor stocks.

Failure awaits any nation when its "human harvest becomes bad." The increase of feeble-mindedness in this country is becoming alarming to all those who are interested in the future of the race. America is threatened with mental and moral degeneracy, through the unbridled multiplication of the unfit.

Every child born into the world should come of good stock. By "good stock" the eugenist means one relatively free from undesirable unit characters, alcoholism, feeble-mindedness, epilepsy, insanity, pauperism, and criminality. All of these should be excluded from the highest function of the race, parenthood.

The world's greatest asset is its baby crop. Probably about fifty million children are born every year. Two and a half millions of these babies appear in the United States. When we think of the power often exerted by one man in this country, by a Lincoln, or an Edison, or a Burbank, we see something of the potential power of these two and a half millions. But wait a moment; nearly half a million of these children die before they are a year old, and a half of all of them die before they are twenty-three, and these have not affected the world at all. Nor is this all, for of the twelve hundred thousand who come to maturity each year, forty thousand will be ineffective through temporary sickness, four or five thousand will be shut up in institutions, "unknown thousands will be kept in poverty through mental deficiency, other thousands will be the cause of social disorder, and still other thousands will be required to tend and control the weak and unruly." Probably fully one hundred thousand are non-producing or only slightly productive. Something like five hundred fifty thousand are our yearly increase of solid, intelligent workers. The one hundred thousand each year who are below normal and whose proportions are slowly but surely increasing, demand our attention. As a nation we are supporting half a million insane, feeble-minded, epileptic, blind, and deaf, eighty thousand prisoners and one hundred thousand paupers, at a cost of over one hundred millions of dollars every year. At the present time this exceeds the amount spent on our public schools to train the normal children of the nation.

Here is a mass of dependents and delinquents, who form an overwhelming impediment to the advancement of the race. Sympathy or charity can do little but keep them at the same level, while heredity is allowed to produce them unchecked. We must "dry up the springs that feed the torrent of this defective and degenerate protoplasm." Davenport has estimated from New Jersey statistics, that the number of epileptics doubles every thirty years. At the present rate of increase in a very few hundred years the number of idiots and insane will equal the number of normal persons. Crime is a disease whose cause is in heredity or environment, or both, and we permit it to flourish in every community. It should be evident that alcoholism, epilepsy, feeble-mindedness, venereal diseases, insanity and criminality should form bars to parenthood.

In order to be sure of good stock one should know the history of three successive generations; among them should be none of the defective unit characters just mentioned. So long as your ancestors were sober, sane and honest you have a good inheritance. One may well be proud of such a family record. The fact that you are preparing yourselves for more effective living argues that good qualities must predominate in your inheritance.

If fifty years from now, a similar group of girls is studying this subject in this city, the chances are that some of you will figure as their ancestors. The past has indeed furnished the variegated web of your characters, but your responsibility is to the future; what kind of an ancestor are you going to be? Wisdom and courage will both be needed, if this sacred flame of life you carry shall be passed on undimmed.

This is not a matter for legislation, save in the cases of defectives and delinquents. It is a matter of enlightened public opinion. This must come as a strong conviction, first among the more intelligent section of each community where it will be followed by those who think less, but are apt imitators, that children are the product, the net result of the present generation. This being recognized, they will not be left to chance for parentage.

What we need to realize, is what is best in the interests of the race; to get into our minds a broader view of humanity, and see it as it has struggled upward through the past, under heavy handicaps. It is an infinitely pathetic spectacle, this long procession of human beings whose greatest, and ever increasing burdens are due to their ignorance. Once a person gets such a view, and sees not only the multitudes of the past, but the number yet to be born, all pressing on to some invisible goal, and all heavily burdened, he will never willingly add to these burdens.

Each normal person born into the world owes society some form of service. If your service to society is to add to the world's children, see to it that the heredity you give them is a desirable legacy.

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